Skipanon River Sediment Evaluation

Abstract

1. Skipanon River sediments are suitable for in-water and upland disposal. Although the sediments were barely above screening levels for cadmium, mercury, total HPAHs, some individual PAHs and DDT degradation products, the results of previous studies and a review of the literature indicate no unacceptable adverse environmental impacts other than those normally associated with in-water disposal.

Introduction

2. The Skipanon River empties into the west side of Youngs Bay on the south side of the Columbia River at about river mile 10.7 (figure 1). The drainage basin for the Skipanon River is about 15 square miles. The river flows from Cullaby Lake, the source, to the Columbia River some 8 miles distant. Tidal effects extend upstream to river mile 4.5.

3. The Federal navigation project consists of a channel 30 feet deep and 200 feet wide extending from the Columbia River navigation channel to Skipanon river mile 2.0 (figure 1). At about river mile 1.5 the channel widens into a turning basin that extends to river mile 1.8 where the channel narrows again and proceeds to the bridge at river mile 2.0. Because of a lack of need for a deep channel, the maintenance depth of the channel is 16 feet and the maintenance depth of the turning basin is 12 feet below mean lower low water (MLLW).

4. Over the past 15 years 865,561 cubic yards (cy) of material has been dredged from the Skipanon channel (range: 14,345 - 291,493 cy). Most of this material has been placed upland at a nearby site east of the river (≈797,396 cy). Sediments have been placed at Tansy Point an in-water, flow lane site located 1 mile downstream from the mouth of the Skipanon River (≈ 11,000 - 24,000 cy). A small amount has been placed at Area D, an in-water site in the north channel at Columbia River mile 7.0. Usually, the channel is dredged from the mouth to the beginning of the turning basin with the turning basin rarely being dredged.

Previous studies

5. Previous studies of sediments from the Skipanon River conducted in 1980, 84, 86 and 87 have shown the sediments to be high in fines with a silt content usually greater than 80 % and clay content averaging 22 %. The organic content, as measured by volatile solids, was around 8.0 %.

6. The last formal sediment evaluation report of Skipanon River sediments, based on the 1980 study, was written in April 1981 (1). The report recommended that Skipanon River sediments were suitable for in-water disposal at Tansy Point, located downstream from the mouth of the Skipanon River just off the south shore of the Columbia River or, at Area D in the Columbia River at approximately river mile 7.0. Upland disposal was recommended providing the site was managed so that dissolved oxygen, ammonia, pH and turbidity of receiving water were within acceptable levels in the downstream mixing zone.

7. The recommendations of the 1981 sediment evaluation were based on the following observations. The concentrations in bulk sediment of arsenic, cadmium, organic carbon,

copper, nitrogen, phosphorus and zinc exceeded Corps guidelines. However, elutriate tests showed that only organic carbon and nitrogen exceeded receiving water guidelines. These receiving water guidelines were based on EPA's water quality criteria. It was concluded that short term elevated levels of carbon and nitrogen (ammonia) would be lowered by mixing and dilution in receiving water; especially in the fast moving Columbia River. Furthermore, from May 1976 to April 1977 EPA conducted sediment toxicity bioassays on Skipanon River sediments taken from near the fishing marina at river mile 1.7(2). The bioassays consisted of 5 replicates on 5 estuarine organisms. These bioassays revealed that there were no significant differences in mean survival of test organisms compared to controls.

8. The U.S. Army Corps of Engineers has established guidelines in a Tiered Testing system which trigger chemical analyses of sediment for potential contaminant problems (3). The guidelines suggest testing sediment for pollutants if the fines content exceeds 20 % and the volatile solids content exceeds 5 %. The results are also used in Clean Water Act (CWA) or Marine Protection, Research and Sanctuaries Act (MPRSA) evaluations of environmental impact of disposal of dredged sediments into fresh water or ocean water disposal sites. This could include bioassays of the sediment for toxicity effects. Because of the known silty nature of Skipanon River sediments, and following CWA and CENPP guidelines, the 1980, 86 and 87 studies included chemical analyses of the sediments. Samples taken this March, 1991 were also subjected to chemical analyses for the same reasons.

Methods

9. Sediment samples were taken by gravity corer at 7 stations between the mouth of the Skipanon River and the end of the turning basin at river mile 1.8, on 3 March, 1991 (figure 1). The stations were located on the side slopes of the approved Federal Project navigation channel. The core lengths averaged 4.5 feet (range 2.8 - 5.7 ft) which was well within range of depth of the sediment layer to be dredged. The cores revealed no obvious layering differences so the entire core lengths were sub-sampled for physical and chemical analyses. Sediment from each station was placed in a baggie and taken to CENPD Materials Lab in Troutdale, Oregon where standard physical tests were performed that measured grain size, resuspended density, void ratio, specific gravity and volatile solids content of the samples. Grain size distributions were determined by passing sediment samples through standard sieves and, if necessary, hydrometer analysis was performed to determine distribution of silt and clay size particles.

10. Also, at each station, a sediment sample was taken for chemical analyses. The samples were taken using an acid cleaned, stainless steel spatula. Samples were placed in acid cleaned glass jars topped with teflon lined lids. They were cold stored until delivery to Columbia Analytical Services (CAS), Kelso, Washington. Samples SK-3 and 4 and SK-5 and 6 were composited to form two samples (SK-3/4 and SK-5/6). Chemical analyses were conducted using standard EPA protocols (see analytical report in appendix). Total Organic Carbon (TOC), metals, pesticides, polychlorobiphenyls (PCBs), polyaromatic hydrocarbons (PAHs) and phenols were measured. Tributyltin (TBT) was measured, using an in-house method, in sample SK-5/6 taken from the mooring basin on the south side of the river. In all, the concentrations of 56 chemicals were determined in each sample.

11. A sub-sample of SK-5/6 was sent to ARDL, Inc., Mt. Vernon, Illinois as a quality assurance measure. The same chemical parameters were measured in this sample. The CENPD materials lab in Troutdale, Oregon provided a quality assurance report of the results.

Results

Physical

12. The sediments were high in fines (mean 94.4 %) with an average median grain size of 0.013 mm which is in the range of fine to medium silt (table 1). The mean clay content was 22.8 %. The mean volatile solids content, a rough measure of organic material in the sediment, was 7.6 %. TOC, a more accurate measure of organic carbon averaged 26.6 mg/g of sediment. Between the mouth of the Skipanon River and the turning basin, the samples appeared to trend towards smaller grain size, less sand, more fines, clay and volatile solids. These results are similar to those of past studies indicating little has changed in sedimentation patterns. The high fines, volatile solids and TOC indicate a potential for accumulation of contaminants should the sediments be exposed to them.

Chemical

Metals

13. The results of metals analyses are presented in table 2. The levels of cadmium in samples SK-1, 3/4, 5/6, and 7 exceeded the EPA, Region 10 and U. S. Army Corps of Engineers, Portland District (CENPP) screening levels (0.96 - 1.0 ppm). The concentration of zinc in SK-3/4 (166 ppm) narrowly exceeded the EPA screening level (160 ppm). While mercury did not exceed the EPA screening level (0.21 ppm), it did exceed the CENPP screening level (0.15 ppm) for samples SK-3/4 and SK-5/6. With the exception of SK-1, the above samples are all in the turning basin near the commercial fishing marina. In general, the samples in the channel leading up to the turning basin had lower concentrations of metals than turning basin samples.

PCBs

14. No PCBs were detected in any sample (table 3). If PCBs were present they were below the detection limit for the analysis (10 ppb). Previous studies had found low levels ,16-45 ppb, in samples from the turning basin and at river mile 2.0 just upstream and even at the mouth of the Skipanon River (28 ppb, in 1980).

Pesticides

15. The DDT degradation products 4',4'-DDE and/or 4',4'DDD were above EPA screening level concentrations (6.9 ppb, total for DDT, DDD and DDE) in some samples (table 3). Surprisingly, SK-1, from the mouth of the river, contained the greatest total concentration of the two degradation products (26 ppb). Otherwise, samples from the turning basin contained 6-18 ppb of total DDD and DDE. Previous studies of Skipanon sediments (1980 and 84) had shown totals of 17.8 and 29.9 ppb. Another study conducted in 1987 found no DDT or its degradation products. Three out of five studies have shown detectable levels of DDD and/or DDE and their total concentrations are near the screening level. It seems safe to state that the two degradation products of DDT are present in the river sediments at levels approaching concern.

16. None of the 17 other pesticides were detected in the sediments.

PAHs

17. Several PAHs were detected in the samples (table 4). In fact, 16 of 17 PAHs were detected. Samples SK-3/4 and SK-5/6 had measurable amounts of 14 and 15 PAHs respectively. The other samples (SK-1, 2 and 7) showed measurable amounts of 11 PAHs each. The pattern of PAHs in the samples was similar, with there being more high molecular weight (HPAHs) than low molecular weight (LPAHs) PAHs. In each sample HPAHs were about 5 times more abundant than LPAHs.

18. The total PAHs in samples SK-3/4 (2,560 ppb) and SK-5/6 (2,040 ppb) exceeded EPA and CENPP guidelines (2,410 and 1,500-2,000 ppb). The total of HPAHs in sample SK-3/4 (2,160 ppb) exceeded the EPA, Region 10 screening level (1,800 ppb). Also, in sample SK-3/4, the PAHs pyrene (560 ppb) and indeno (1,2,3-cd) pyrene (160 ppb) exceeded EPA screening levels (430 and 69 ppb respectively). Indeno (1,2,3-cd) pyrene also exceeded the screening level in sample SK-5/6. Previous studies in 1986 and 87 found undetectable amounts of PAHs. However, the detection limits for these earlier analyses ranged from 100 to 7700 ppb, whereas the current limits were 20 to 40 ppb. Samples from the channel leading up to the turning basin had lower concentrations of PAHs than turning basin samples.

Phenols

19. Five different phenols were analyzed for in the sediment samples. Phenol was detected in 4 samples ranging in concentration from 20 to 80 ppb (table 4). Also, 4-methylphenol was detected in 4 samples (40-100 ppb). Two phenols, 2-methylphenol and 2,4-dimethylphenol were undetected but the detection limit of the method (20 ppb) was higher than the EPA screening level (10 ppb). Pentachlorophenol was also undetected and the detection limit was below the EPA screening level. Besides having anthropogenic sources, phenols can be associated with decaying vegetation and are found in bark. Some of the phenols found in the Skipanon River sediments may be from such decaying vegetation. There are log rafts along the river and a wood processing plant has been observed blowing wood chips into the water during barge loading operations. Phenols were not measured in previous studies of Skipanon sediments. The levels reported here are below screening levels and should be rapidly degraded by bacteria. The concentrations of phenols found in Skipanon River sediments are about the same as those from a clean sandy area in the Columbia River, at about river mile 6 near Area D, which had phenol levels between 20 and 100 ppb (4).

TBT

20. The TBT concentration was measured in one sample from the area of the commercial boat basin (SK-5/6). The concentration is somewhere between 1.4 and 10.1 ppb and is below concern level. The reason for the uncertainty is because CAS and ARDL differed in their reports of the concentration of TBT. Since neither lab had a TBT protocol, both sent a sub-sample of sediment to the same lab (Battelle, NW) for the TBT analysis. The reported results from this lab, though different, are most likely due to normal laboratory variation. Although sample SK-5/6 was thoroughly homogenized before sub-samples were distributed to CAS and ARDL, it is possible too that a local paint chip may have contributed to the difference. In any event, the higher measure of 10.1 ppb is below the EPA, Region 10 screening level (30 ppb).

Quality Assurance/Control

21. The following is a summary of the quality assurance (QA) and quality control (QC) report submitted by CENPD Materials Lab, Troutdale, Oregon. That official report is in the enclosed appendix.

22. Sub samples of sample SK-5/6 were sent to CAS and ARDL as a quality assurance measure. Both analytical labs reported similar concentrations of analytes that agreed within a factor of two to each other or detection limits. The one discrepancy was for TBT (1.4 and 10.1 ppb). These results were not within a factor of two of each other. Both CAS and ARDL sent a sub-sample of SK-5/6 to Battelle, NW for TBT analysis. According to the QA report, the discrepancy in the results reported by Battelle, was assumed to be due to contamination of one of the sub-samples. The fact that the concentrations found in the method blanks of the two analyses agreed also suggested possible contamination . [However, a conversation with Lisa Lefkowitz, the lab person in charge of the analysis, indicated that the different results could also be due, as mentioned above, to normal analytical variability or to "patchiness" of the sample since only a small paint chip could change the measured concentration of TBT.]

23. Matrix spike recoveries for metals and, in general, surrogate recoveries for other analytes were within acceptable QC criteria, especially since inter lab QA results agreed. The relative percent differences (RPD) of lab duplicates for metals were within QC limits. Lab blanks were free of contamination. Detection limits met project requirements. In the future, different labs, instead of the same lab, will be used to measure TBT which should result in a more useful cross check.

Discussion

24. Channel sediments between the mouth and the turning basin appear to have lower concentrations of pollutants than turning basin sediments. The turning basin has two boat docks, located on opposite sides, which may be contributing to this difference perhaps from local petroleum spills and boat maintenance activities. The dock on the south side of the river supports commercial fishing boats and smaller boats as well. The dock on the north side of the river supports smaller boats.

Water column impacts

25. The level of cadmium and mercury in bulk sediment barely exceeded EPA and/or CENPP screening levels. Cadmium and mercury have a high toxicity and bioaccumulation capacity. However, the level of cadmium/mercury in the Skipanon sediments is probably of low environmental impact to the water column. This is supported by earlier studies in 1980 and 1987 which showed that elutriates of Skipanon sediments, that had similar cadmium/mercury levels to current levels, did not exceed EPA water quality criteria for both fresh and salt water (1,5). This was also true of elutriates of sediments taken from the west channel into Baker Bay, Chinook Channel and Tongue Point, which had similar fines and cadmium/mercury content as Skipanon samples (6,7,8). The effect on the water column of dissolved contaminants from Skipanon River sediment is expected to be minimal, especially in fast water regimes of the lower Columbia River, where any dissolved contaminants would rapidly be diluted.

Solid phase impacts

27. The effect of the cadmium and mercury in sediment on benthic invertebrates is also expected to be minimal. Sediments from New York Harbor, which were very similar to Skipanon sediments in their sand, silt, clay and organic content, but 4 to 30 times higher in cadmium and 19 to 233 times higher in mercury content, were tested on three organisms; a filter feeding clam (Mercenaria mercenaria), a deposit feeding sand worm (Nereis virens) and a shrimp (Palaemonetes pugio). After 100 days of exposure to the sediments the three organisms showed no significant bioaccumulation of cadmium or mercury when compared to controls, (9). It was speculated that the lack of bioaccumulation was due to high organic content and sulfur content of the sediments. The cadmium may have been bound to the organic matter in a non bioavailable form or, it may have been bound to sulfur as an insoluble cadmium or mercury sulfide. Since then research has shown that, when the ratio of acid volatile metals (AVM) to acid volatile sulfide (AVS) in sediment is ≤ 1.0, the toxicity of cadmium, and other heavy metals including mercury, is negligible. Although AVS was not measured in the current Skipanon sediment samples, samples taken in 1986 showed considerable elemental sulfur (4). It is probable that Skipanon River sediments have protective AVS which forms insoluble cadmium and mercury sulfides. In the future, Skipanon sediments will be analyzed for AVS.

28. Additional evidence that Skipanon River sediments will have little impact on benthic organisms comes from the result of studies conducted by EPA during 1976-77 (2) and Battelle (10). The results of the EPA study showed that when 5 estuarine organisms were exposed to Skipanon sediment there was no significant difference from controls in the mean survival of any species. The Skipanon River sediments have changed very little over the years. They have similar fines, TOCs and metals. PAHs have recently been detected, probably because of improved detection limits. Levels of PCBs and pesticides have remained about the same. In addition to this EPA bioassay study, another study of similar sediment from Tongue Point, conducted by Battelle, Pacific NW Division, revealed no significant mortality to benthic organisms compared to controls (10). There was no significant bioaccumulation of metals even though cadmium and mercury in Tongue Point sediments were 20 times higher than the concentrations in disposal site F sediments. PAHs were also not bioaccumulated. The Tongue Point sediments were then disposed at site F an Ocean Dredged Material Disposal Site (ODMDS) located off the mouth of the Columbia River.

Recommendations

29. According to Clean Water Act (CWA) 404 (b) guidelines sediments from the Skipanon River are suitable for unconfined in-water disposal with no unacceptable adverse environmental impacts expected. Because of the high energy, dispersive nature of these sites, impacts are expected to be temporary. Disposal is acceptable upland, at an approved site, providing receiving water in the mixing zone is monitored for acceptable levels of dissolved oxygen, ammonia and turbidity. Other similar, lower Columbia River estuary sediments have been disposed in-water with no unacceptable adverse environmental impacts. For comparison, Table 5 shows physical and chemical parameters of these sediments in relation to Skipanon River sediments.

30. In-water disposal at an ODMDS, such as Site F off the mouth of the Columbia River, should be acceptable. Tongue Point sediments, which are similar to Skipanon sediments, were determined to be acceptable for disposal at Site F. No unacceptable, adverse environmental

impacts are expected to result from such disposal. Water column impacts should be low because as stated in the discussion, elutriate tests confirm that water quality criteria are not exceeded for cadmium and mercury. Solid phase impacts should also be minimal as bioassays of Skipanon and Tongue Point sediments revealed no significant differences in survival of organisms in test sediments and control or reference sediments.

31. In future sediment evaluations, Skipanon sediments will be checked for acid volatile sulfide (AVS). Because of conflicting reports on the concentrations of DDT and its degradation products DDD and DDE, these pesticides should also be monitored in future studies.

Figure 1.

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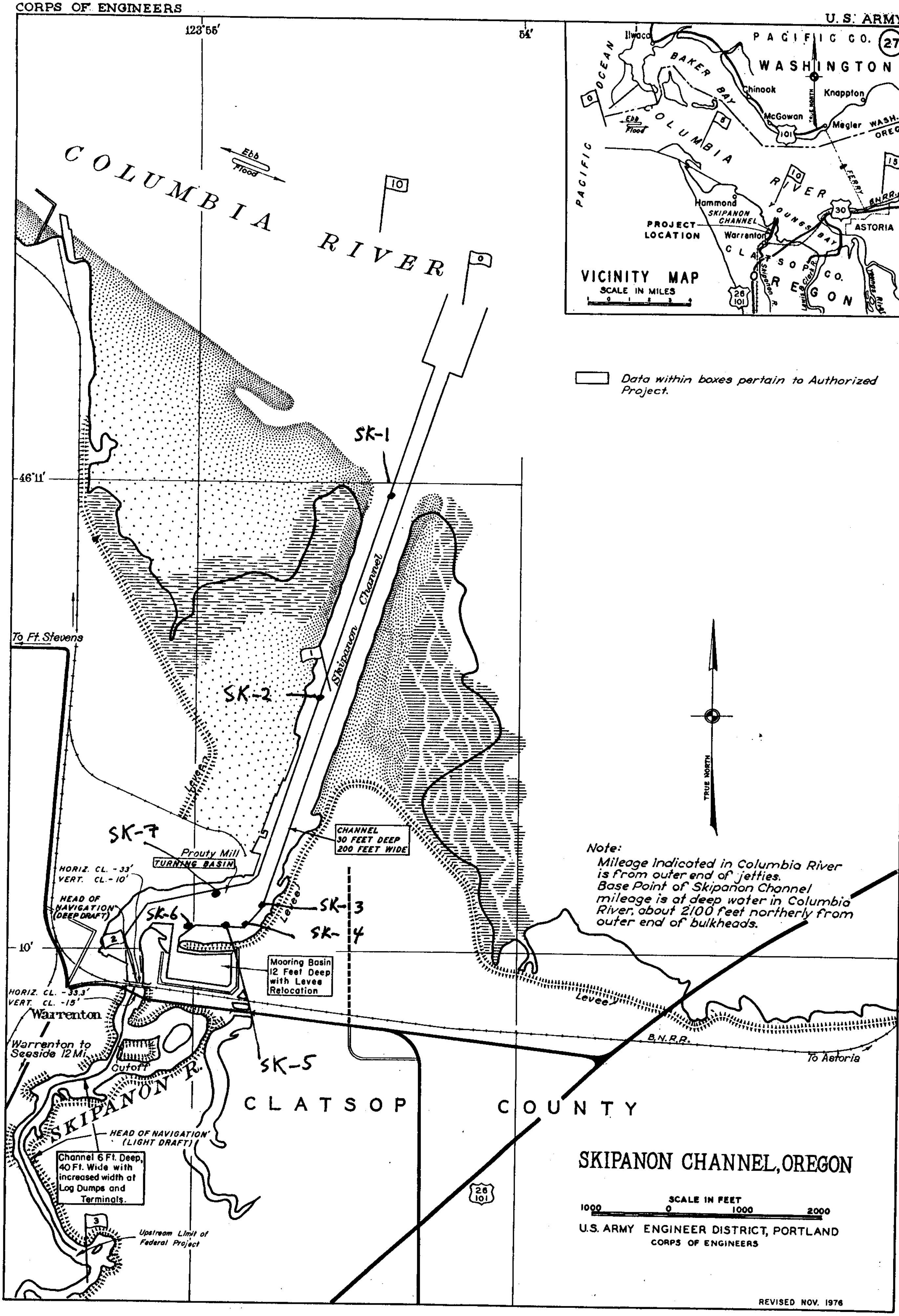

Table 1.

Grain size, sediment distribution, volatile solids and total organic carbon in Skipanon River sediments.

sample	median grain size	size distribution sand	fines	clay	volatile solids	TOC
	mm		%		%	mg/g
SK-1	.023	14.3	85.7	13.2	4.9	22.7
SK-2	.020	9.5	90.5	16.4	7.1	32.3
SK-3	.007	3.6	96.4	37.3	10.4	28.9†
SK-4	.011	3.7	96.3	21.6	8.4	
SK-5	.009	2.1	97.9	25.8	1.1*	26.4†
SK-6	.011	3.5	96.5	22.4	7.9	
SK-7	.010	2.4	97.6	22.8	7.0	22.5
mean	.013	5.6	94.4	22.8	7.6	26.6

* Suspect considering the values of the other samples. A re-measurement yielded 31 % which is also suspect because the re-sample was not representative of the original sample.

† value for composited samples SK-3/4 and SK-5/6.

Table 2.

Metals concentrations in Skipanon River sediments.

sample	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
				ppm				
SK-1	6	1.0*	21	32	18	0.13	19	112
SK-2	4	0.9	24	43	23	0.14	18	124
SK-3/4	10	1.8*	30	48	8	0.18*	21	166*
SK-5/6	10	1.6*	27	49	7	0.16*	22	154
SK-7	8	1.2*	24	51	5	0.15*	17	142
mean	8	1.3*	25	45	12	0.15*	19	140
S.L. (EPA)	57	0.96	180	81	66	0.21	140	160
S.L. (CENPP)	40	1.0	20-300	50	40	0.15	-	250

* Exceeds either EPA, Region 10 or CENPP screening levels of concern.

S.L. (Screening Level)

Table 3.

Concentrations of PCBs and pesticides in Skipanon River sediment.

sample	PCBs	DDT degradation products			other pesticides†
		DDE	DDD	total	
			ppb		
SK-1	nd	5	21*	26*	nd
SK-2	nd	nd	nd	nd	nd
SK-3/4	nd	8*	10*	18*	nd
SK-5/6	nd	3	15*	18*	nd
SK-7	nd	nd	6	6*	nd

† 17 other pesticides were analyzed for with detection limits ranging from 1-30 ppb.

* Exceeds either EPA (6.9 ppb) or CENPP (10-15) screening levels of concern.

15-20

Table 4.

Concentrations of PAHs and phenols in Skipanon River sediments.

sample	SK-1	SK-2	SK-3/4	SK-5/6	SK-7
			ppb		
PAHs					
naphthalene	40	30	70	60	30
2-methylnaphthalene	-	-	20	20	-
acenapthalene	-	-	20	-	-
dibenzofuran	-	-	-	20	-
acenaphthene	-	-	-	30	-
fluorene	-	20	30	40	-
phenanthrene	80	70	190	180	60
anthracene	20	30	70	60	30
total LPAHs	140	150	400	410	120
fluoranthrene	120	90	380	130	170
pyrene	120	150	560*	400	170
benzo(a)anthracene	60	80	170	160	80
chrysene	80	100	210	210	100
benzo(b+k)fluoranthene	140	160	330	320	170
benzo(a)pyrene	60	70	190	170	60
indeno(1,2,3-cd)pyrene	50	50	160*	120*	40
dibenzo(a,h)anthracene	-	-	-	-	-
benzo(g,h,i)perylene	50	50	160	120	40
total HPAHs	680	750	2,160*	1,630	830
total PAHS	820	900	2,560*	2,040*	950
PHENOLS					
phenol	-	80	20	60	40
4-methylphenol	50	40	100	60	-
total phenols	50	120	120	120	40

* Exceeds EPA, Region 10 or CENPP screening level guidelines.

Table 5.

Comparison of selected physical and chemical parameters of Skipanon River sediments with sediments from other lower Columbia River sites.

	physical					chemical			
site	med. gr. size	sand	fines	vol. solids	TOC	Cd	Hg	total PAHs	DDT
	mm		%		mg/g	ppm		ppb	
Skipanon	0.013	5.6	94.4	7.6	26.6	1.3	0.15	1,454	13.6
Tongue Pt.*	0.075	18.6	81.4	4.0	8.7	1.1	0.15	997	2.2
Ilwaco chl†	0.019	18.8	81.2	4.8	8.1	0.6	0.10	500	-
Chinook chl^	0.017	15.0	85.0	5.3	10.4	0.6	0.08	446	-

* From Battelle, NW report (10).
† From 1987 samples IL 1-5 only.
^ From 1986 Chinook samples 5-11 and 1987 samples 5,7,10.

all data taken from CENPP sediment database.

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